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(56) Documents Cited
GB 2285729 A GB 1356276 A WO 98/09478 A
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(54) Abstract Title
Heating pads for garments

(57) This invention relates to heating pads for garments which are waterproof and can thus be washed and function underwater eg in a diving suit. The pad comprises a carbonised material 2, bus bars 3 in electrical contact with said carbonised material; an outer skin material 8 bonded to a first side of the carbonised material; a coated insulating material 6 bonded to a second side of the carbonised fabric; wherein the edges of the outer skin material are sealably bonded to the edges of the coated insulating material. Material compositions are disclosed.

A control system, incorporated into a waterproof control box is provided to control the temperature during warming up and normal operation in response to sensors. A thermal cut out is provided. A piezoelectric percussion switch switches the pad on/off.

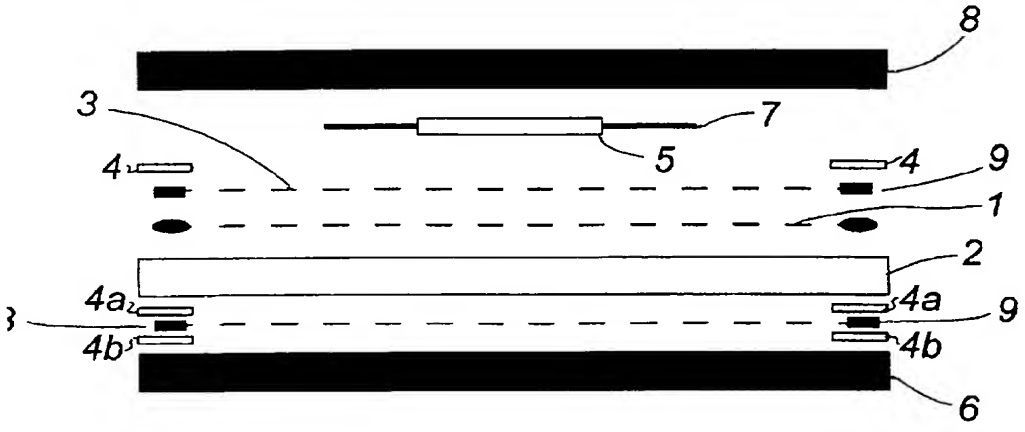

FIG. 2

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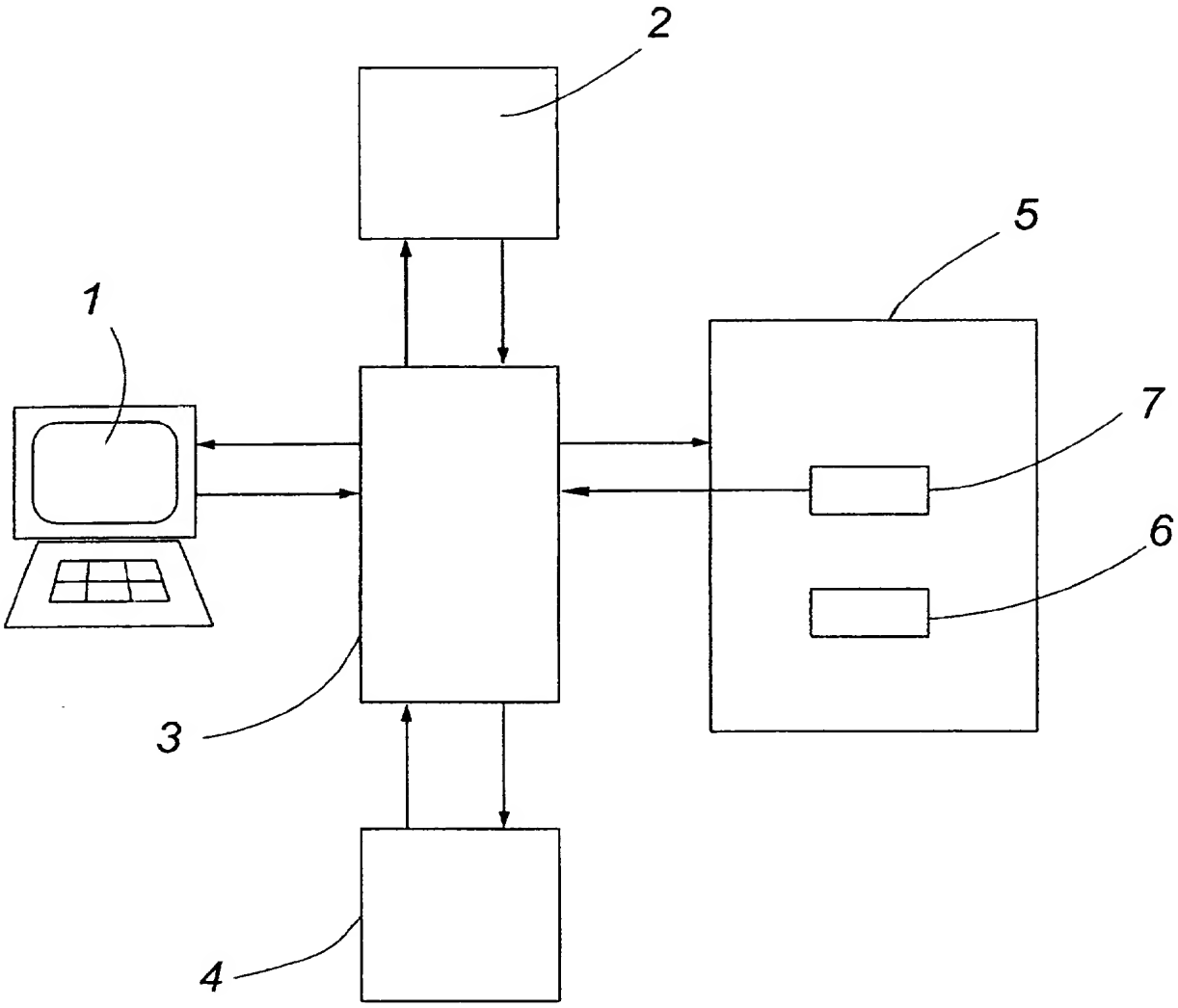
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1



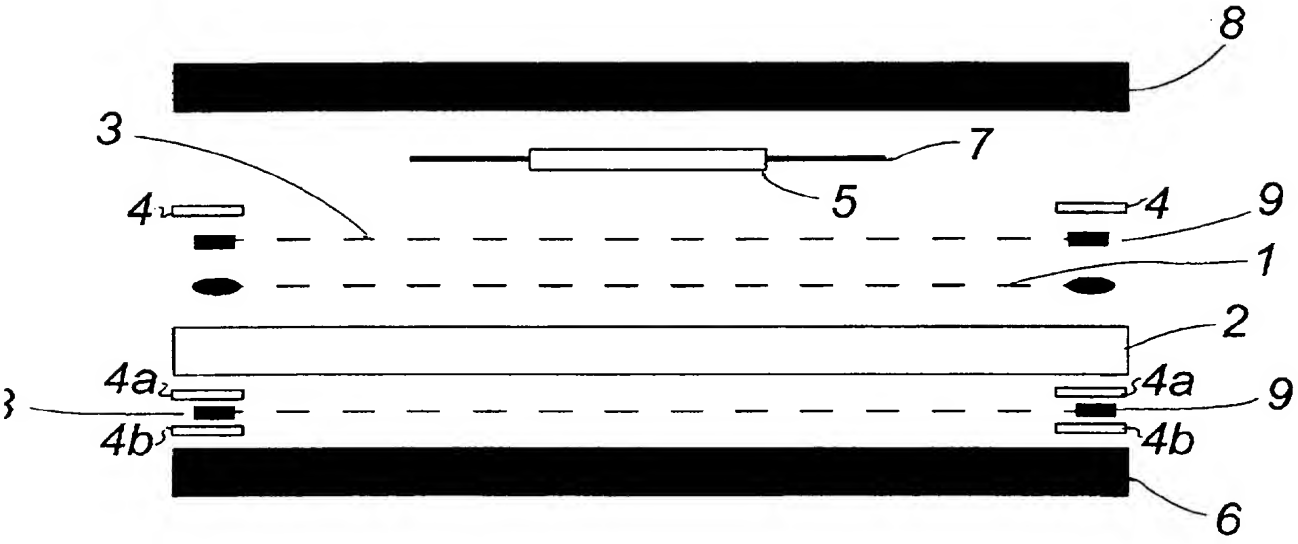


FIG. 2

HEATING PADS FOR GARMENTS

The present invention relates to a heating pad comprising a carbonised material which may be used for example in heated all in one suits.

WO-A-95/18517 (BTG Ltd) discloses a conductive element comprising a carbonised fabric connected to a low voltage electrical supply and encapsulated between insulating layers. The carbonised fabric is stated to be useful as a resistance heater in a number of applications when driven by low voltages (i.e. voltages which are safe for exposure to human or animal users of the fabric).

The present invention is based on the recognition that the heating properties of carbonised materials may be exploited in other fields, in particular for use in conditions of extreme cold e.g. in deep sea diving gear.

Presently, it is known to use heat insulating neoprene to manufacture deep sea diving suits. These suits are however heavy and rigid making them uncomfortable for the diver and hampering his mobility. They provide little or no effective protection at the extremities (i.e. arms, legs, head) where extreme cold may have its severest effect.

To enable the existing technology to adapt to such environments, heating assemblies which will not malfunction in wet conditions or at high pressures need to be developed. This need is of greater significance when it is appreciated that wet Conditions may increase the danger of electric shock to the user. User safety is of course paramount. The present invention seeks to fulfil this need.

Thus viewed from a first aspect the present invention provides a waterproof heating pad comprising a carbonised material.

The present invention has the advantage of typically allowing only minimal ingress of water and/or gas at pressures of up to 10 bar. It is a further advantage that the heating pads are washable in aqueous based detergents. In a preferred embodiment, the waterproof heating pad is provided with waterproof operating means (eg electronic control means).

Viewed from a further aspect the present invention provides a heating pad comprising a carbonised material wherein said pad is capable of withstanding high

pressure (e.g. pressure typically encountered in diving).

In a preferred embodiment, the pad capable of withstanding high pressure is provided with operating means capable of withstanding high pressure. The invention has the advantage of typically allowing egress of any absorbed water/gas as pressure is reduced from 10 bar to 1 bar.

The pads of the invention will typically withstand pressures of up to 3 bar, preferably up to 5 bar, more preferably up to 7 bar and especially preferably up to 10 bar.

The term 'carbonised material' and associated terms as used herein are familiar to those skilled in the art and are discussed for example in WO-A-95/18517. For the purposes of the present invention, any carbonised material may be used in any form. Generally, the selection of and tailoring of the carbonised material is within the capability of the man skilled in the art. Thus for example the carbonised material may be in the form of a fabric (e.g. a woven fabric) or a sheet or web of any desired weight or consistency.

In one preferred embodiment, the heating pad comprises bus bars in electrical contact with said carbonised material; an outer skin material bonded to a first side of the carbonised material; a coated insulating material bonded to a second side of the carbonised fabric; wherein the edges of the outer skin material are sealably bonded to the edges of the coated insulating material.

The insulating material of the coated insulating material referred to above may be any known material which is an electrical insulator and which is waterproof. Nylon is preferred. The coating may be any flexible material which is compatible with the insulating material on which it is coated, The combination of coating and insulating material should not degrade in the presence of heat (typically up to 100^{0}C) or cold (typically down to -40^{0}C), in the presence of solvents, detergents, saltwater or any substance it may contact during use eg. air, oxygen and gases used in diving (eg Nitrox, Heliox, Tri-mix, Argon and the like). Butyl is the preferred coating because it has the advantage of being thin yet still impervious to the above materials.

With regard to the outer skin material, any waterproof flexible material which deforms minimally under pressure and has some thermal resistance may be used. Neoprene is preferred.

Viewed from a yet further aspect the present invention comprises a process for preparing a heating pad as hereinbefore defined. Preferably the process comprises the following steps:

(a) arranging bus bars in electrical contact with a carbonised material;

(b) attaching a wiring harness to an outer skin material;

(c) applying an electrically insulating coating to any exposed conductors or components;

(d) bonding the outer skin material to the carbonised material;

(e) bonding a coated insulating material to the opposite side of the carbonised material of the assembly prepared in step (d);

(f) sealably bonding the edges of the outer skin material to the edges of the coated insulating material.

Bus bars may be any conventional type such as an electrically conductive foil or strip (e.g. copper foil or strip), a moulded plastic, a silicone elastomer or wire sewn into carbonised cloth or attached to carbonised cloth. Preferably the bus bar is a woven copper braid, particularly preferably with a conductive coating (to reduce the possibility of oxidisation or reaction with other materials). The bus bar may be held in electrical contact with the carbonised material either indirectly or directly by known methods e.g. by stitching, adhesive tapes, silicone elastomers and the like. Preferably, the preferred woven wire braid for use in the present invention is

attached by adhesive tape. Conveniently the bus bar is separated from the carbonised material by a conductive interface medium which improves electrical contact between the carbonised material and the bus bar. This medium may be made of any conventional material suitable for the purpose. Preferably an electrically conductive paste, paint, tape, material or adhesive is used.

Steps (b), (d), (e) and (f) in the preferred process of the invention are carried out using any adhesive bonding composition. Preferred are compositions which do not require heating to be activated. Thus preferred for the coating on the coated insulating material is butyl which may be activated by a chemical activator such as Satreat. A two part adhesive is preferred for use in one or more of steps (b) to (e) and particular preferred in this regard is the adhesive known as S2000. In general, however, any adhesive may be used provided the adhesive used between the bus bars, conductive interface medium and carbonised material is one which is electrically conductive. The avoidance of heating steps wherever possible to achieve bonding is advantageous given the delicate nature of electronic components which may be present in the heating pad.

For the purposes of step (a), an adhesive tape may be used. Any tape may be appropriate provided it is an electrical insulator. Preferably the adhesive tape is one which comprises a hot melt adhesive capable of providing a gas and waterproof seal on heating.

The pad may also be provided with a thermal cut-out PCB as discussed hereinafter which is conveniently bonded to the assembly by means of a bonding/adhesive composition as discussed above, preferably S 2000. The thermal cut-Out may also carry a temperature sensor and the whole assembly is treated with an electrically insulating coating.

The wiring harness typically comprises conductors to supply power to the pad, conductors for remote temperature sensing (i.e from the pad thermistor to the control box), thermistors or other temperature control/sensing devices and a thermal cut-out (over-temperature protection).

At any point in the latter stages of the process, the assembly may be rolled

to expel trapped air.

A further advantageous feature which has been recognised in the development of prior art heating pads is in the specific arrangement of the carbonised material and the wire braid. Known heating pads comprise a carbonised fabric in which power is applied to one end of each bus bar. However, pads of this type have been found to give unequal amounts of heat along the length of the fabric. It has been found that a substantially even heating effect may be obtained by separating the wire braid on one side of the carbonised material from the carbonised material and connecting both ends of the braid to the appropriate power terminal (positive or negative). Thus the wire braid which is not in direct contact with the carbonised material merely serves to carry current to and from the remote end of the pad.

Thus viewed from a yet still further aspect the present invention provides a heating pad comprising a carbonised material one side whereof is in electrical contact with a woven wire braid and the opposite side whereof is not in electrical contact with the woven wire braid. Preferably non-contact of the two components is maintained by means of adhesive tape.

Notwithstanding the fact that the present invention is primarily envisaged for uses in which waterproofing is desirable, it may nevertheless be used in a significant number of other uses including inter alia undergarments, overgarments, heated diving suit systems, survival clothing, snow mobile suits, motor bike suits, therapeutic medical garments (e.g. hypothermia blankets; blankets for shock sufferers), car seats, heated blankets, heated mats, jackets, waistcoats, etc. Also any heated clothing which may be immersed or may come into contact with a liquid for any reason e.g. washing the garment.

Viewed from a further aspect the present invention provides a heatable garment comprising one or more heating pads as hereinbefore defined.

Preferably the use will be in garments where it is desired to maintain body temperature. Particularly preferably the invention will be embodied in heated diving suit systems where it represents a significant advance in deep sea diving allowing

the diver to use suits in which heating pads of the invention help to maintain body temperature. Most advantageously, heating may be provided directly at or close to the extremities where the severest effects of cold are normally felt.

Viewed from a still further aspect the invention provides the use of heating pads comprising carbonised materials in heated diving suit systems. Preferably the heating pads are waterproof and/or capable of withstanding high pressure and preferably are located at or near to one or more bodily extremities.

One particular advantage of the present invention is that it is possible to manufacture a garment capable of providing localised heating. This is achieved simply by varying the location of the pad within the garment. Preferably the pads will be removably mounted and capable of being fixed anywhere in the garment before use. Thus, for example, in conditions of extreme cold it is essential to maintain the body temperature of the extremities i.e. hands, feet, head. This is achievable with relative ease in accordance with the invention by appropriate location of the pads. In certain circumstances, it may be desirable to locate pads other than at the extremities e.g. on or near the heart. Preferably the garment comprises 2 or more pads, particularly preferably 4, 5 or more pads and up to 7 pads may be useful.

The pads within the garments of the invention may conveniently be operated by electronic control means either external to or integral with the garment. Suitable electrical control systems are known to those skilled in the art and are able to adjustably and controllably vary the heat output of the pad. However for underwater use the control means are provided in a waterproof housing and preferably are capable of withstanding high pressures. For this purpose any conventional waterproof housing may be used, although polyurethane encapsulant is preferred for protection against shock, mechanical stress or ingress of water or gases. Similarly power to the system may be controlled by a waterproof percussion switch conveniently located. Preferably the switch comprises a piezoelectric element which produces an electric pulse when deformed and a microprocessor or circuitry which senses the pulses. In use, the switch is tapped twice within a second to

activate/deactivate the suit. One particularly preferred embodiment of the invention is a diving suit system comprising one or more waterproof heating pads externally or internally operable by waterproof control means and activated by a waterproof percussion switch.

The invention is now illustrated in a specific embodiment by reference to the accompanying drawings.

Figure 1: a schematic representation of the pad and control system

Figure 2: a cross sectional representation of a heating pad of the invention.

With reference to figure 1, temperature sensing is carried out by a temperature sensor (7) comprising NTC (negative temperature coefficient) thermistors or other sensors located between the carbonised fabric and the butyl-coated nylon. The thermistor provides a temperature measurement which is independent of stress, deformation or ageing of the carbonised fabric. Each thermistor or sensor forms part of a sensing network capable of producing a voltage or signal proportional to the temperature of the pad (5).

Temperature sensing is conducted in the following steps:

(i) Warmup cycle. This is instigated at power up and on subsequent resets of the system. The temperature of the or each pad is sampled and power is applied to the pad for a suitable period. The temperature is sampled again. If the temperature has not risen to a level which indicates that the pad is functioning correctly, this process is repeated up to two (or a suitable number of) further times. If the temperature has not risen to a satisfactory level (possibly indicating malfunction or damage to the pad) then power input to the pad is disabled.

(ii) Normal operation. The temperature of the pad is sampled each second or at a suitable sampling interval. This value is compared with the target value and used to calculate the duty cycle (percentage of the following second or suitable interval in

which power is applied to the pad) in order to bring the actual temperature to the desired temperature.

(iii) Temperature adjustment. The target temperatures can be altered via a detachable personal computer interface. (1). The altered values may be downloaded to the control processor which stores these values in an EEPROM (Electrically Erasable Programmable Read Only Memory) (4).

The system may also be provided with a watchdog microprocessor (2). Every twenty five milliseconds or suitable period the watchdog processor sends a logic level ('high' or 'low') to the control processor (3). The control processor complements this level and returns it. If the control processor does not respond for thirty seconds or suitable interval the watchdog disconnects power from all the pads and resets the control processor,

The thermal cutout (6) comprises a thermistor or sensor (mounted Close to the control thermistor or sensor) and circuitry which will prevent current flowing through the pad should the temperature exceed 45°C or suitable value under any circumstances. Hysteresis is incorporated which will not allow power to the pad until the temperature has dropped to an arbitrary value (5°C or similar below the cutout temperature). This will alert the user to a malfunction.

In addition to the waterproof power connector, the control box is completely sealed in polyurethane encapsulant for protection against shock, mechanical stress or ingress of water or gas.

Power to the system is controlled by a waterproof percussion switch which is incorporated in the drysuit penetrator. It comprises a piezoelectric element, which produces an electric pulse when deformed and a microprocessor which senses the pulses. In use, the switch is tapped twice within a second to enable the microprocessor to activate the suit. If the switch is subsequently tapped as described above, power to the suit is disabled.

With reference to figure 2, a heating pad according to the invention is constructed as follows. A conductive interface medium (1) is applied to a carbonised fabric (2). A bus bar in the form of a conductive coated copper braid (3) is attached to the conductive interface medium by means of adhesive tape. The copper braid is folded over a further strip of adhesive tape (4a) laid on the reverse side of the assembly and covered with a further layer of adhesive tape (4b) Heat shrinking sleeves (9) are applied to the copper braid tails.

A thermal cut out PCB (5) is attached to the assembly and to a suitable supply cable.

Skin/cell neoprene (6) is first coated with S2000 two part adhesive. Satreat is applied to the butyl side of a portion of butyl coated nylon (81 which is then first coated with S2000.

A wiring harness (not shown) and the carbonised fabric are first coated with S2000. Having been allowed to dry, the wiring harness is second coated with S2000 and attached to the skin/cell neoprene.

S2000 is applied over the reverse side of the thermal Cut Out PCB and neoprene tape and rubber strain relief (7) are applied.

S2000 is applied to the carbonised fabric and skin/cell neoprene and the two are bonded together.

The complete assembly is coated with S2000 and the butyl coated nylon is second coated with S2000. The two are then bonded together before the assembled pad is rolled for a first time to displace any trapped air. The pad is reversed and S2000 is applied to the skin neoprene edges and to overhanging butyl. The butyl is folded and bonded to the edges of the skin neoprene. As a final step, the complete assembly is mechanically rolled.

CLAIMS

1. A waterproof heating pad comprising a carbonised material, the heating pad further comprising bus bars in electrical contact with said carbonised material; an outer skin material bonded to a first side of the carbonised material; a coated insulating material bonded to a second side of the carbonised fabric; wherein the edges of the outer skin material are sealably bonded to the edges of the coated insulating material.

2. A waterproof heating pad according to claim 1 characterised in that the insulating material of the coated insulating material is Nylon, the coating being any flexible material which is compatible with the insulating material on which it is coated.

3. A waterproof heating pad according to any of the preceding claims characterised in that the coating is Butyl.

4. A waterproof heating pad according to any of the preceding claims characterised in that the outer skin material is Neoprene.

5. A process for preparing a heating pad comprising the following steps:
(a) arranging bus bars in electrical contact with a carbonised material;
(b) attaching a wiring harness to an outer skin material;
(c) applying an electrically insulating coating to any exposed conductors or components;
(d) bonding the outer skin material to the carbonised material;
(e) bonding a coated insulating material to the opposite side of the carbonised material of the assembly prepared in step (d);
(f) sealably bonding the edges of the outer skin material to the edges of the coated insulating material.

6. A waterproof heating pad according to any of the preceding claims characterised in that the bus bars are of woven copper braid with a conductive coating.

7. A waterproof heating pad according to claim 6 characterised in that the woven copper braid is attached by adhesive tape

8. A waterproof heating pad according to any of the preceding claims characterised in that the bus bar is separated from the carbonised material by a conductive interface medium.

9. A waterproof heating pad according to claim 8 characterised in that the conductive interface medium is an electrically conductive paste, paint, tape, material or adhesive.

10. A process according to claim 5 characterised in that steps (b), (d), (e) and (f) are carried out using an adhesive bonding composition which does not require heating to be activated.

11. A process according to claim 5, 10, characterised in that the coating on the coated insulating material is butyl, and in that the bonding of this coating is facilitated by a chemical activator.

12. A process according to any of claims 5, 10, 11 characterised in that a two part adhesive is used in one or more of steps (b) to (e)

13. A process according to claim 12 characterised in that the adhesive known as S2000 is used.

14. A process according to any of claims 5, 10, 11, 12 characterised in that an adhesive tape is used in step (a).

15. A process according to claim 14 characterised in that the adhesive tape is one which comprises a hot melt adhesive capable of providing a gas and waterproof seal on heating.

16. A waterproof heating pad according to any of the preceding claims characterised in that the pad is also be provided with a thermal cut-out PCB.

17. A waterproof heating pad according to claim 16 characterised in that the thermal cut-out also carries a temperature sensor and the whole assembly is treated with an electrically insulating coating.

18. A waterproof heating pad according to any of the preceding claims characterised in that the wiring harness comprises conductors to supply power to the pad, temperature control/sensing means, conductors for remote temperature sensing (i.e from the pad temperature control/sensing means to the control box), and a thermal cut-out.

19. A process according to any of claims 5, 10, 11, 12, 13, 14, 15 characterised in that the pad is rolled to expel trapped air.

20. A heating pad comprising a carbonised material one side whereof is in electrical contact with a woven wire braid and the opposite side whereof is not in electrical contact with the woven wire braid.

21. A heating pad according to claim 20 characterised in that non-contact of the two components is maintained by means of adhesive tape.

22. A heatable garment comprising one or more heating pads according to any of the preceding claims.

23. A heatable garment according to claim 22 characterised in that the garment is a heated diving suit

24. A heatable garment according to either of claims 22, 23 characterised in that the heating pads are waterproof and/or capable of withstanding high pressure and are located at or near to one or more bodily extremities.

25. A heatable garment according to any of claims 22, 23, 24 characterised in that the pads are removably mounted and capable of being fixed anywhere in the garment before use.

26. A heatable garment according to any of claims 22, 23, 24, 25 characterised in that the garment comprises 2 or more pads, particularly preferably 4, 5 or more pads and up to 7 or more pads.

27. A waterproof heating pad according to any of claims 1-21 characterised in that a control means therefor is provided in a waterproof housing capable of withstanding high pressures.

28. A waterproof heating pad according to any of claims 1-21, 27 characterised in that polyurethane encapsulant is used to encapsulate the control means and protect same against shock, mechanical stress or ingress of water or gases.

29. A waterproof heating pad according to any of claims 1-21, 27, 28 characterised in

that power to the pad is controlled by a waterproof percussion switch.

30. A waterproof heating pad according to claim 29 characterised in that the switch comprises a piezoelectric element which produces an electric pulse when deformed and a microprocessor or circuitry which senses the pulses.

31. A diving suit comprising one or more waterproof heating pads according to any of claims 1-21, 27, 27, 29, 30 characterised in that the pads are externally or internally operable by waterproof control means and activated by a waterproof percussion switch.

The Patent Office

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Application No: GB 9906100.4
Claims searched: 1-19

Examiner: John Cockitt
Date of search: 10 August 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H5H [HBA2, HBH2, HAJ]

Int Cl (Ed.6): H05B [3/04, 3/34, 3/54, 3/56, 3/58]

Other: ONLINE: EPODOC, WPI, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A,Y	GB2285729A	BRITISH - carbonised fabric sealed between insulating layers	1 at least
Y	GB1356276A	DU PONT - see fig	1 at least
Y	US4245149A	FAIRLIE - see figs	1 at least
X	US4250398A	DELPHIC - see equivalent structure and carbon element	1 at least
Y	WO9809478A	GUREVICH - see figs	1 at least
Y	FR002764678A	LMCA - see online abstract - coated fabric insulation	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.